Original Article

Robotic-Assisted Laparoscopy vs Conventional Laparoscopy for the Treatment of Advanced Stage Endometriosis

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ABSTRACT   **Study Objective:** To compare robotic-assisted laparoscopy with conventional laparoscopy for treatment of advanced stage endometriosis insofar as operative time, estimated blood loss, complication rate, and length of hospital stay.
Study Design: Retrospective cohort study (Canadian Task Force classification II2). All procedures were performed by one surgeon between January 2004 and July 2012. Data was collected via chart review.
Setting: Tertiary referral center for treatment of endometriosis.
Patients: Four hundred twenty women with advanced endometriosis.
Interventions: Fertility-sparing surgery to treat advanced endometriosis, either via conventional or robotic-assisted laparoscopy.
Measurements and Main Results: Patient demographic data, operative time, estimated blood loss, complication rate, and length of hospital stay were compared between the 2 groups. Two hundred seventy-three patients underwent conventional laparoscopy and 147 patients underwent robotic-assisted laparoscopy for fertility-sparing treatment of advanced stage endometriosis. Patients in both groups had similar characteristics insofar as age, body mass index, and previous abdominal surgeries. There were no significant differences in blood loss or complication rate between the 2 groups. Mean operative time in the conventional laparoscopy group was 135 minutes (range, 115–156 minutes), and in the robotic-assisted laparoscopy group was 196 minutes (range, 185–209 minutes), with a mean difference in operative time of 61 minutes (p < .001). Length of hospital stay was also significantly increased in the robotic-assisted laparoscopy group. Most patients who underwent conventional laparoscopy were discharged to home on the day of surgery. Of 273 patients in the conventional laparoscopy group, only 63 remained in the hospital overnight, and all 147 patients in the robotic-assisted laparoscopy group were discharged on postoperative day 1.
Conclusion: Conventional laparoscopy and robotic-assisted laparoscopy are excellent methods for treatment of advanced stages of endometriosis. However, use of the robotic platform may increase operative time and might also be associated with longer hospital stay. Journal of Minimally Invasive Gynecology (2015) 22, 40–44 Published by Elsevier Inc. on behalf of AAGL.

Keywords: Advanced stage endometriosis; Conventional laparoscopy; Robotic-assisted laparoscopy

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Endometriosis is a complex disease that affects 10% to 50% of women of reproductive age worldwide [1,2]. Currently, laparoscopic surgery is considered the gold standard for diagnosis and treatment of endometriosis [1,2]. For advanced endometriosis (stages III and IV), laparoscopic treatment can be technically difficult and is often reserved for use by specialists in laparoscopic techniques [1]. For this reason, many surgeons still perform laparotomy for treatment of advanced stage endometriosis.

The advent of computer-enhanced technology such as the surgical robot has enabled many surgeons to convert from use of laparotomy to robotic-assisted laparoscopy [3–5]. Several publications have compared conventional laparoscopy with robotic-assisted laparoscopy for common gynecologic procedures such as hysterectomy and myomectomy. The data support robotic-assisted laparoscopy as a feasible approach to minimally invasive surgery for use by surgeons not comfortable with performing conventional laparoscopy [5–17]. However, of those publications, only 3 were randomized controlled trials, and few specifically addressed advanced stage endometriosis [18–24]. The objective of the present study was to evaluate the safety and efficacy of robotic-assisted laparoscopy vs conventional laparoscopy for treatment of advanced stage endometriosis.

Material and Methods

This was a retrospective cohort study of all consecutive patients undergoing fertility-sparing treatment of advanced stage endometriosis from January 2004 to July 2012. Institutional review board approval was not required because of the retrospective nature of the study. Data were collected via review of electronic and paper medical records.

In all patients, the indication for surgery was pain and/or infertility. Patients were included if they had undergone fertility-sparing treatment of endometriosis during the study period. Patients were selected to undergo robotic-assisted laparoscopy or conventional laparoscopy strictly on the basis of availability of the patient on the robot operating room day. No clinical parameters were used to guide the surgical technique. Patients were excluded if they were found to have stage 1 or 2 endometriosis or if they needed bladder, ureteral, or bowel resection (including disk excision) or hysterectomy, myomectomy, or thoracoscopy.

All surgical procedures were performed at a tertiary endometriosis referral center by the same surgeon (C.N.), who has extensive experience with both conventional laparoscopy and robotic-assisted laparoscopy. He was also involved in the original development and testing of the da Vinci robot [25], and thus his experience dates back to the laboratory testing of the da Vinci Surgical System.

For all procedures, the patient was placed in the conventional dorsal lithotomy position with the legs in Allen stirrups. After the abdomen was entered, hysteroscopy and chromopertubation were performed, and a HUMI manipulator (Harris-Kronner Uterine Manipulator Injector; CooperSurgical, Inc., Trumbull, CT) was placed in the uterus. Three 5-mm trocars were placed for conventional laparoscopy. For robotic-assisted laparoscopy, one 12-mm trocar, two 8-mm trocars, and one 5-mm assistant trocar were used until 2011, when the 8-mm trocars were replaced by 5-mm robotic ports. Most cases also included cystoscopy and proctoscopy at the end of the surgical procedure to early recognize and treat potential genitourinary and/or gastrointestinal injuries, respectively.

For robotic-assisted laparoscopy, the da Vinci Surgical System (Intuitive Surgical. Inc., Sunnyvale, CA) was initially docked centrally when using the first-generation system, then side docked on the patient's right side when the second- and third-generation da Vinci robots became available. The suprapubic trocar was used as the assistant port, and the operating surgeon controlled 2 robotic arms from the console. Use of the third robotic arm is deemed cumbersome by our group. From experience, not only does it increase the possible risk of torching and blind injury to tissue but it also requires an extra incision.

The instruments used for robotic-assisted treatment of endometriosis included scissors, a monopolar hook, a grasper, a needle holder, and a suction/irrigator probe [26]. For conventional laparoscopy, the instruments included a CO_2 laser or PlasmaJet (Plasma Surgical, Inc., Roswell, GA), a grasper, a bipolar system, a suction/irrigator probe, and a needle holder if needed [26].

Electronic and paper medical records were reviewed to evaluate operative time, estimated blood loss, and intraoperative and postoperative complications. Operative time was calculated on the basis of the anesthesia record of surgery start and end times. This included abdominal entry, placement of trocars, hysteroscopy, docking of the robot, surgeon console time, undocking, cystoscopy, proctoscopy, and closure of trocar sites. Estimated blood loss was calculated by measuring the blood collected in the suction canisters and subtracting the amount of irrigation used during the surgery. Preoperative and postoperative complete blood cell counts were then compared for accuracy. Complications were graded according to the Clavien-Dindo classification of surgical complications [27]. Only important complications classified as grade III to V were recorded.

Comparisons were made between the conventional and robotic-assisted laparoscopy groups using the Mann-Whitney test and *t*-test analysis. A p value <.05 was considered statistically significant.

Results

A total of 420 patients underwent conservative treatment of stage III or IV endometriosis during the study period. Of these, 273 patients underwent conventional laparoscopy and 147 underwent robotic-assisted laparoscopy. Five patients in the conventional laparoscopy group were originally scheduled to undergo robotic-assisted laparoscopy. However, the robot was not docked because of the presence of extensive extrapelvic endometriosis. Because the robotic camera is not interchangeable between ports and the arms are not so easily maneuverable in extrapelvic sites, use of the robotic platform would have been time consuming and intricate. Three procedures in the robotic-assisted laparoscopy group were converted to conventional laparoscopy for the same reason. Data for these 3 patients were included in the robotic-assisted laparoscopy analysis because the robotic ports were placed, the da Vinci robot was docked, and a

portion of the procedures was completed with assistance of the robotic platform.

Baseline characteristics of age, body mass index, and mean number of previous surgeries were similar in both groups (Table 1). Mean estimated blood loss was 25 mL in the conventional laparoscopy group, and 40 mL in the robotic-assisted laparoscopy group, which did not reach statistical significance. Mean operative time in the conventional laparoscopy group was 61 minutes shorter than in the robotic-assisted laparoscopy group: 135 vs 196 minutes, p < .001.

All 147 patients in the robotic-assisted laparoscopy group remained in the hospital overnight, and were discharged on postoperative day 1, whereas in the conventional laparoscopy group only 63 of 273 patients (23.1%) stayed overnight. Most patients in the conventional laparoscopy group were discharged to home on the day of surgery. This difference is statistically significant (p < .001). There were no major complications in either group, according to the Clavien-Dindo classification of surgical complications [27].

Discussion

This large retrospective cohort study supports the use of both conventional laparoscopy and robotic-assisted laparoscopy for treatment of advanced stage endometriosis. The study findings are consistent with those in the literature that demonstrate that use of the surgical robot increases overall operative time [8,16,20]. Even with an experienced surgeon and operating room team, operative time was longer with use of the robotic surgical system (mean, >1 hour; range, 29–94 minutes). Several factors, in addition to the time needed to dock and undock, likely contribute to the increased operative time.

In the case of large endometriomas, trocar placement and removal of the specimen may have increased operative time. On occasion, an extra trocar was needed, and it was difficult to manipulate the robotic arms, in particular if the patient was very thin and/or short. In addition, there was substantial delay in removing cyst wall pieces or endometriosis specimens because they all must be passed to the assistant's instrument, then removed, and the assistant's instrument replaced and reoriented. Larger specimens were removed through the larger robotic camera port; however, again this was associated with delay to reposition the bulky camera. Alternatively, we placed an extra 12-mm trocar for specimen removal, which added additional time, expense, and incision, and, as a result, possibly more morbidity and overall cost.

Another option was to keep the larger cyst wall in the pelvis until the end of the procedure. However, visualization of the cul-de-sac might be partially obscured and extra time added if suturing is used to keep multiple pieces aligned so that they do not get lost in the abdomen. In contrast, during conventional laparoscopy, tissue can be rapidly removed in a specimen bag through a 10- or 12-mm umbilical port, with concomitant removal of the trocar under direct visualization using a 5-mm laparoscope.

Not using the CO_2 laser with the da Vinci robot is another factor that may have contributed to the increased operative time in the robotic-assisted procedures. We concur with Berkes et al [28] that, with use of the CO_2 laser, deep infiltrating endometriotic lesions can be easily and efficiently removed with minimal bleeding, because of the physics of the CO_2 laser compared with radiofrequency energy. The robotic scissors and monopolar hook require extra care and time to prevent injury to surrounding structures. This leads to longer operative time, which, in combination with the increased number of incisions and associated pain, is why, in part, hospital stay was longer in the robotic group.

Not uncommonly, disease can also be found in the upper abdomen, around the liver and the diaphragm, and on the appendix, and can consist of extremely large endometriomas that require treatment. In robotic-assisted laparoscopic cases of extensive intra-abdominal endometriosis, there is limited flexibility in changing camera locations and instrumentation.

Table 1

Comparison of conventional laparoscopy vs robotic-assisted laparoscopy

Variable	Conventional laparoscopy (n = 273)	Robotic-assisted laparoscopy (n = 147)	p value
Age, yr, median (range)	31 (19–42)	30 (21–38)	.21
Body mass index, median (range)	23 (19–29)	23 (19–32)	.81
No. of previous abdominal surgeries, median (range)	1 (0–3)	1 (0–3)	.90
No. of patients with previous cesarean section	37	22	.35
No. of patients who underwent previous laparoscopy to treat endometriosis	65	12	<.001
No. of patients who underwent previous laparoscopic appendectomy	5	1	.27
Operative time, min, mean	135	196	<.001
Estimated blood loss, mL, mean	25	40	.86
Intraoperative and postoperative major complications	0	0	NA
Number of patients with hospital stay >24h	63	147	<.001

NA = not available.

For difficult dissections via conventional laparoscopy, the surgeon is able to move the camera to different ports much more readily to ensure that no inadvertent injury has occurred. With the robotic platform, this can only be accomplished using a hybrid technique of conventional laparoscopy and robotic-assisted laparoscopy, as previously described for management of ovarian cancer [29,30]. In the hybrid technique, after exploratory laparoscopy is performed and the extent of disease in the upper abdomen is assessed and treated via conventional laparoscopy, the robotic trocars are placed and the robotic platform is docked for treatment of the disease in the pelvis.

Moreover, identification of retroperitoneal disease can be challenging with the robotic platform because it precludes the use of the laparoscopic suction-irrigator probe to palpate the pelvic floor. This useful technique requires tactile feedback that the robot platform lacks. For these reasons, 8 cases in the present study that were planned robotic-assisted laparoscopic procedures were eventually completed via conventional laparoscopy.

The primary strengths of the present study are the number of patients with advanced endometriosis in each surgical group and the experience of the surgical team. To our knowledge, this is the largest study of conservative treatment of advanced endometriosis via laparoscopy or robotic-assisted laparoscopy published to date. There are no randomized controlled trials in the literature that investigated the robotic platform in conservative treatment of advanced stage endometriosis. Most studies in the literature discuss definitive treatment of endometriosis via hysterectomy with or without bilateral salpingo-oophorectomy [31,32].

The extensive experience of the primary surgeon and the operating room staff are also a major strength of this study. The primary surgeon assisted in the initial development and testing of the da Vinci Surgical System [25]. This experience may resolve the commonly observed longer operative time and increased blood loss observed during the surgeon's and operating room team's learning curve. The present study was begun in 2004, well past the learning curve for the senior author. It should be noted that the experience of different operating room teams was not accounted for in this study.

The primary limitations of the present study are its retrospective nature and limited follow-up. Only high-grade complications were reviewed in the analysis because these tend to have a greater effect on patient care and postoperative quality of life. The low complication rate is likely a combination of the primary surgeon's expertise and lack of documentation and follow-up due to the referral nature of the practice and the retrospective design of the study. Many patients travel from across the United States and also from foreign countries, and are followed up in the long term by their local provider. This may also contribute to underreporting of postoperative complications.

Inasmuch as the selection of laparoscopic and robotic cases was made solely on the basis of schedule availability of the patient and instrumentation, this might be considered a potential flaw. Prospective randomized studies are needed to further evaluate the various surgical methods.

For common gynecologic procedures such as hysterectomy and myomectomy, the robotic surgical system enables surgeons who are not comfortable with conventional laparoscopy to perform minimally invasive surgery sooner [33]. The limiting factor for operative laparoscopy, with or without assistance of the robotic platform, is surgeon skill and experience and availability of proper instruments [26]. The robotic arm enables the general gynecologic surgeon to convert more laparotomies to minimally invasive surgery. Computer-enhanced technology will have an important role in the future of surgery, although in its current infancy it does have limitations.

With an experienced surgeon, it seems that the use of the present robotic platform is safe and effective for treatment of advanced endometriosis. However, compared with conventional laparoscopy, it is more time-consuming, and patients stay in the hospital longer. It should be kept in mind that longer operative time has been correlated with increased overall cost associated with the robotic platform [17,34].

In conclusion, as technology advances, the present limitations of the robotic surgical system will be overcome, and surgeons will be able to perform more minimally invasive surgical procedures, in particular in advanced stage endometriosis. For treatment of advanced stage endometriosis, conventional laparoscopy, with and without robotic assistance, is associated with excellent results. However, use of the robotic surgical system is more time-consuming and is associated with longer hospital stay and overall cost. In our experience, procedures to treat severe disease, requiring multiple exchanges of camera and instruments, and/or large endometriomas are easier to perform using conventional laparoscopy.

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